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The effect of coffee consumption on serum total cholesterol in the Sami and Norwegian populations

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Abstract

Objective: To assess coffee consumption in the Sami and Norwegian populations and to investigate the impact of unfiltered boiled coffee consumption on serum cholesterol concentrations.
Design: A cross-sectional study. Information was collected by self-administrated questionnaires and total serum cholesterol was analysed. Participants were divided into three ethnic groups: Sami I (Sami used as home language in the last three generations), Sami II (at least one Sami identity marker) and Norwegian.
Setting: In an area with Sami, Kven/Finnish and Norwegian populations, the SAMINOR study, 2003–2004.
Subjects: A total of 5647 men and 6347 women aged 36–79 years.
Results: More than 90 % of the study populations were coffee drinkers. Only 22 % were unfiltered coffee consumers. Sami I had the highest proportion of participants who consumed nine or more cups of unfiltered coffee per day, although the number of participants was limited. Total coffee consumption was associated with increased total cholesterol for men ($P < 0{\cdot}01$) and women ($P < 0{\cdot}0001$). For those who drank only unfiltered coffee, a significant association was found only in Norwegian men, adjusted for physical activity in leisure time, BMI and smoking habits ($P < 0{\cdot}001$). From the lowest (less than five cups) to the highest (nine or more cups) unfiltered coffee consumption category, the mean total cholesterol levels increased by 0·29 mmol/l in Norwegian men.
Conclusions: Unfiltered coffee consumption was lower in the present study compared to previous reports. In general, total coffee consumption was positively associated with total cholesterol levels. However, for unfiltered coffee consumption, an association was found only in Norwegian men.

Keywords
Unfiltered coffee
Cholesterol
Sami
Norwegian
Epidemiology

There is a high prevalence of coffee drinkers in Scandinavians. Traditionally, they made their coffee by boiling ground coffee beans in water[1]. When the association between unfiltered coffee consumption and cholesterol concentration became well-publicised in the 1980s, its consumption decreased and a corresponding increase in the consumption of filtered coffee occurred[2]. The Sami people, the indigenous people of Scandinavia and Northern Finland, have traditionally had a high intake of unfiltered coffee[3]. Earlier studies have indicated that the Sami have a higher concentration of total cholesterol and HDL cholesterol than Norwegians[4–6], although Utsi *et al.*[7] reported no ethnic differences.

The relationship between coffee consumption and risk of CHD has been examined in several epidemiological studies. The strong association between coffee consumption and serum cholesterol was first reported by Thelle *et al.*[8] in the population-based Tromsø Heart Study. Another study from the same population showed that consumption of unfiltered coffee was the main explanatory factor[9]. These findings were confirmed by several case–control studies that found high coffee intake (five or more cups) to be associated with increased risk of CHD and myocardial infarction (MI)[10–12]. By contrast, the majority of prospective cohort studies have not found significant associations between coffee consumption and the risk of CHD[12–15]. Furthermore, a prospective study in Norway with a 12-year follow-up reported that CHD mortality risk increased only in those with an intake of more than nine cups of coffee per day[2].

Randomised controlled trials (RCT) have shown that the consumption of unfiltered coffee increased serum total cholesterol concentrations in a dose-dependent manner, whereas a moderate daily intake of filtered coffee was found to have little or no association with increase in serum cholesterol[16]. However, a recent

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prospective controlled study indicated that filtered coffee can also have a cholesterol-raising effect[17].

The two diterpenes in coffee oil, cafestol and kahweol, are the main substances that have a cholesterol-raising effect[18]. They are both natural components of coffee beans and are extracted from ground coffee during brewing; they are largely removed by filtration through paper filters[19]. The highest levels of cafestol and kahweol were found in Scandinavian unfiltered coffee, Turkish coffee and French press (cafetiere) coffee; by contrast, percolated and instant coffee contain low levels[20,21]. A recent case–control study provides evidence that caffeine can increase the risk of CHD depending on the P450 cytochrome genotype[22].

The aim of the present study was to assess the distributions of coffee consumption among the Sami and Norwegian populations, and to investigate the impact of unfiltered coffee consumption on cholesterol levels among these ethnic groups.

Methods

Study population

The Centre for Sami Health Research at the University of Tromsø, in collaboration with the Norwegian Institute of Public Health, conducted a population-based cardiovascular survey in areas with mixed Sami and Norwegian populations, the SAMINOR study, in 2003–2004. The SAMINOR study is a part of the seventh cardiovascular screening in Finnmark, where the Norwegian Institute of Public Health was responsible for the screening part. The survey was also expanded to focus on the health and living conditions among the Sami in Norway. As a consequence, the geographical areas were selected in order to find a high proportion of people with a Sami background and there were municipalities outside of Finnmark County that were also included. The study covered municipalities in Norway where more than 5 % of the population reported themselves to be Sami in the 1970 census[23]. In addition, some of the districts selected were from municipalities with an overall lower proportion of individuals of Sami ethnicity. The districts were selected based on ethnographic knowledge about the Sami population and all inhabitants were invited independent of their ethnic background. The screening procedures and methods have been detailed elsewhere[24].

All inhabitants drawn from the Central Population Register in the defined SAMINOR study area aged 30 and 36–79 years were invited (*n* 27 987). Of these, 16 968 (60·6 %) attended the study.

Participants who were 30 years old were excluded from the analysis because of a small sample size (*n* 328) and a low attendance rate. Our analysis was further restricted to 15 546 participants, aged 36–79 years, who gave consent to medical research and responded to both an initial and a screening questionnaire. In addition, immigrants (*n* 257) and individuals with missing data on ethnicity (*n* 52), coffee consumption (*n* 239) and unavailable blood samples (*n* 133) were excluded.

We also excluded those who used lipid-lowering drugs (*n* 2871). The total numbers for the following analyses were 11 994 individuals, 5647 men and 6347 women.

Ethics approval

The Regional Committees for Medical Research Ethics approved the study. All the participants gave written informed consent.

Questionnaires

Two self-administered questionnaires were used to obtain information concerning coffee consumption, ethnicity, physical activity and use of tobacco. The question on coffee consumption was not part of an extensive dietary survey and has not been validated. We asked the participants how many cups of filtered, boiled or other types of coffee they drank daily. Coffee consumers were grouped into four categories: zero, one to four, five to eight and nine cups or more per day. The information about food habits collected in the present study is too sparse to compute the energy or fat intake for each individual. Age was categorised into 15-year age groups.

The SAMINOR study included questions about the language used at home by the respondents' grandparents, parents and the respondent, and the ethnic background of the parents and the respondent and self-perceived ethnicity (Norwegian, Sami, Kven or other). On the basis of the questions, the participants were separated into three ethnic groups: a Norwegian group and two groups for Sami affiliation. The Sami-affiliated groups were defined as Sami I (Sami used as a home language by all grandparents, parents and the participant – three generations); Sami II (at least one Sami identity marker, e.g. language, self-perceived ethnicity or family background). Kven respondents with no Sami identity markers (a people of Finnish origin) were included in the Norwegian group.

Smoking habits were categorised as follows: current smoker, previous smoker and never smoked. Information on leisure physical activity was based on one question with four response categories: (i) sedentary (reading, watching television, etc.); (ii) moderately active (walking, cycling at least 4 h/week); (iii) strenuous exercise and sports activities at least 4 h/week; and (iv) regular hard physical training for competitions. The last two categories were merged and classified as hard physical activity.

As already indicated, selected participants had never used lipid-lowering drugs. This was achieved by asking the question: 'Do you take cholesterol lowering medication?' Participants were then stratified by use into three categories: 'currently', 'previously, but not now' and 'never used'. Information on brand names for all medications was also collected. Participants who answered 'never used' or gave no information on brand name were designated as 'never used' (12 233).

Laboratory analyses and physical examinations

Non-fasting venous blood samples were drawn at enrolment. The samples were left to coagulate for a minimum of 30 min and were centrifuged within 1·5 h. Serum was sent by overnight mail to the laboratories in Oslo and stored at −70°C. Serum total cholesterol was measured directly by an enzymatic method (Hitachi 917 auto analyser; Roche Diagnostics, Roche, Switzerland). Seronorm lipoprotein was used as internal quality control material for lipid analyses. Control samples were analysed at the start of each batch and for every 30th sample. The interassay CV for total cholesterol was 3 %. All laboratory measurements were conducted at the Laboratory of the Department of Clinical Chemistry, University Hospital in Ullevål, Oslo, Norway.

Body weight (in kilograms to one decimal place) and height (in centimetres to one decimal place) were measured with an electronic height and weight scale, with the participants wearing light clothing and no shoes. BMI was calculated as kg/m^2.

Statistical methods

The data management and statistical analyses were processed by using the SAS for Windows statistical software package version 9·1 (SAS Institute Inc., Cary, NC, USA). The means of sample characteristics were compared among ethnic groups by using ANOVA and the proportions by using χ^2 tests. Ethnic differences in the mean number of cups of coffee per day were tested by analysis of covariance (ANCOVA), adjusted for age groups and gender. Coffee consumption was stratified by the three ethnic groups, gender and 15-year age groups; the ethnic differences were tested by using a Cochrane–Mantel–Haenszels test, adjusted for age.

Age-adjusted mean levels of total cholesterol according to cups of coffee per day were performed by one-way ANCOVA. Tests for linear trend were performed by using multiple linear regression analysis, adjusted for age group, physical activity in leisure time, BMI and smoking habits.

Results

Selected characteristics of the study population are given in Table 1. The Sami I group was older than both the Norwegian and the Sami II sub-populations. Sami I had a more sedentary activity in leisure time, higher proportions of current smokers and a higher level of mean BMI. The average number of cups of coffee consumed daily was 6·7 cups by Sami I individuals compared with 5·2 cups for Norwegians. The mean levels of unfiltered coffee consumption were highest for Sami I (3·2 cups) compared with Norwegians (1·6 cups; $P < 0·0001$).

Table 2 shows the distribution of coffee drinking habits according to ethnicity, age, gender and brewing methods. Total coffee consumption was high in this population; almost 90 % were coffee drinkers. The proportion of

Table 1 Characteristics of the study group of men and women (*n* 11 994) by ethnic groups (the SAMINOR study 2003–2004)

	Sami I (*n* 1332)		Sami II (*n* 2665)		Norwegian (*n* 7997)		
	n	%	*n*	%	*n*	%	*P* value*
Age (years)							
36–49	516	39	1194	45	3355	42	
50–64	548	41	1073	40	3336	42	
65–79	268	20	398	15	1306	16	<0·0001
Gender							
Men	629	47	1294	49	3724	47	
Women	703	53	1371	51	4273	53	0·2
Physical activity in leisure time							
Sedentary	348	29	585	24	1693	22	
Moderate	674	56	1468	60	4495	61	
Hard	191	16	400	16	1268	17	<0·0001
Smoking habits							
Current	449	34	933	35	2555	32	
Previous	413	31	882	33	2683	34	
Never	459	35	828	31	2693	34	0·01
	Mean	SD	Mean	SD	Mean	SD	
BMI (kg/m^2)	28·0	4·5	27·5	4·4	27·1	4·3	<0·0001
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	
Cups of coffee per day							
All brewing types	6·7	6·5, 6·8	5·8	5·7, 5·9	5·2	5·1, 5·3	<0·0001
Filtered coffee	2·8	2·6, 3·0	3·5	3·3, 3·6	3·1	3·0, 3·2	<0·0001
Unfiltered coffee	3·2	3·0, 3·4	1·8	1·6, 1·9	1·6	1·5, 1·7	<0·0001
Other coffee	0·7	0·6, 0·8	0·6	0·5, 0·6	0·5	0·4, 0·5	0·0001

*The ethnic differences were tested by χ^2 tests and ANOVA (BMI). Ethnic differences in means of coffee consumption were tested by analysis of covariance, adjusted for age and gender.

Table 2 Distribution of coffee consumption (% of participants) by ethnicity according to brewing methods, gender and age (the SAMINOR study 2003–2004)

	Sami I Cups of coffee per day				Sami II Cups of coffee per day				Norwegian Cups of coffee per day				
	0	<5	5–8	≥9	0	<5	5–8	≥9	0	<5	5–8	≥9	*P* value*
All brewing types (*n* 11 994)													
Men		*n* 629				*n* 1294				*n* 3724			
36–49	2	14	41	43	6	21	43	30	6	28	43	23	
50–64	3	21	38	38	4	28	40	28	4	32	45	19	<0·0001
65–79	2	30	46	22	2	36	46	16	3	47	38	12	
Women		*n* 703				*n* 1371				*n* 4273			
36–49	5	27	43	25	8	33	42	17	9	37	40	14	
50–64	3	33	41	23	4	35	42	19	5	43	43	10	<0·0001
65–79	2	49	35	14	4	52	40	4	4	59	33	4	
Filtered coffee (*n* 11 994)													
Men													
36–49	42	15	26	17	32	27	27	14	31	29	28	12	
50–64	46	16	24	14	32	26	28	14	31	30	29	10	<0·0001
65–79	59	15	18	8	43	22	28	7	47	27	21	5	
Women													
36–49	47	27	19	7	30	36	25	9	36	35	22	7	
50–64	51	27	17	5	33	27	29	11	33	37	25	5	<0·0001
65–79	57	25	12	6	42	35	21	2	45	34	19	2	
Unfiltered coffee (*n* 11 994)													
Men													
36–49	45	19	20	16	60	19	13	8	60	23	10	7	
50–64	51	17	15	17	66	15	11	8	68	17	10	5	<0·0001
65–79	52	15	21	12	61	18	15	6	63	19	13	5	
Women													
36–49	44	26	17	13	65	21	10	4	65	20	11	4	
50–64	50	17	20	13	70	15	10	5	69	17	11	3	<0·0001
65–79	54	23	16	7	68	21	10	1	67	21	11	1	

*Ethnic differences in coffee consumption were tested by Cochrane–Mantel–Haenszel tests, adjusted for age.

those who consumed more than nine cups of coffee per day was highest among Sami I men aged 36–64 years. Sami I men and women in all age groups had the highest proportion of high consumption (nine or more cups per day) of unfiltered coffee compared with the Norwegian and Sami II groups.

Table 3 shows the age-adjusted mean level of total cholesterol according to coffee consumption for all the three ethnic groups and overall. Total cholesterol level increased with increasing total coffee intake among Norwegian men ($P = 0{\cdot}05$) and Norwegian ($P < 0{\cdot}0001$), and Sami II ($P = 0{\cdot}003$) women. Consumption of filtered coffee had no effect on total cholesterol level. In participants who only consumed unfiltered coffee, an increase in total cholesterol with increasing coffee consumption was shown for Norwegian men ($P = 0{\cdot}001$), adjusted for age group, physical activity in leisure time, BMI (kg/m^2) and current smoking habits. From the lowest (less than five cups) to the highest coffee consumption (nine or more cups) category, the mean serum cholesterol level increased by 0·29 mmol/l in Norwegian men.

Discussion

We found a high rate of coffee consumption in this population; more than 90 % were coffee drinkers. However, only 22 % drank unfiltered coffee exclusively. The highest unfiltered coffee consumption was among Sami I men and women. Our results did not strongly affirm previous reports of a positive association between unfiltered coffee intake and total cholesterol in the Sami. This association was found only for Norwegian men.

A limitation of our study is that the information on the type of coffee and its consumption was collected by a self-administrated questionnaire. In addition, we have no information about the sizes of the cups used and it is likely that the size varied considerably for the subpopulation and individually. The question on coffee consumption was not validated in any way; consequently, there is a possibility for misclassification. However, it is hard to assume that the misclassification would be different between the ethnic groups.

The attendance rate was 60 %, similar to that of other population-based studies. We have limited information about non-respondents, except that they tended to be young, single and male. We do not know the attendance rate in each ethnic group, because information about ethnicity could only be collected at the screening site. The attendance rate of 60 % could imply a risk of selection bias. However, another Norwegian study that examined non-response in a community sample found no differences in the prevalence of disease and exposure between those who did and those who did not respond[25]. To avoid bias, we have selected participants not using lipid-lowering drugs. Those who used lipid-lowering drugs

Table 3 Age-adjusted mean levels of serum total cholesterol (mmol/l) in men and women according to cups of coffee per day by brewing type and ethnicity (the SAMINOR study 2003–2004)*

	Men (*n* 5647)						Women (*n* 6347)					
		Cups of coffee per day						Cups of coffee per day				
	Number of participants	0	<5	5–8	≥9	*P* value†	Number of participants	0	<5	5–8	≥9	*P* value†
All brewing types (*n* 11 994)												
Sami I	629	5·48	5·96	6·12	6·13	0·07	703	6·22	6·23	6·08	6·13	0·09
Sami II	1294	5·74	6·15	6·13	6·13	0·73	1371	5·73	6·10	6·14	6·32	0·003
Norwegian	3724	5·81	6·02	6·06	6·10	0·05	4273	5·93	6·11	6·25	6·37	<0·0001
Overall	5647	5·77	6·04	6·08	6·11	0·01	6347	5·90	6·12	6·21	6·32	<0·0001
Filtered coffee (*n* 5590)‡												
Sami I	229		6·00	6·04	5·86	0·56	234		6·19	5·99	6·10	0·60
Sami II	593		6·19	6·05	6·06	0·12	671		6·10	6·10	6·08	0·77
Norwegian	1804		6·00	5·91	6·03	0·32	2059		6·13	6·21	6·27	0·43
Overall	2626		6·04	5·95	6·02	0·12	2964		6·13	6·17	6·20	0·81
Unfiltered coffee (*n* 2652)‡												
Sami I	211		6·11	6·31	6·34	0·52	251		6·18	6·16	6·13	0·27
Sami II	275		6·21	6·30	6·07	0·63	258		6·21	6·29	6·35	0·78
Norwegian	762		6·02	6·36	6·31	0·001	895		6·21	6·27	6·42	0·18
Overall	1248		6·07	6·34	6·25	0·009	1404		6·20	6·25	6·33	0·86

*Means are age-adjusted by analysis of covariance.
†Tests for linear trend were performed using multiple linear regression analysis, adjusted for age groups, BMI (kg/m^2) and physical activity in leisure time and smoking habits.
‡The numbers in the filtered and unfiltered coffee group corresponded to those who only drank that specific type of coffee.

might have reduced their coffee consumption because of high cholesterol or because of the advice of a doctor.

Coffee consumption was high in our survey; over 60 % of the participants drank five or more cups daily, whereas the Sami men had an even higher consumption. However, only 22 % of the participants were unfiltered coffee consumers, whereas 36 % consumed a combination of unfiltered coffee and other types of coffee. In 1986–1987, unfiltered coffee (68 % of both sexes) was the predominant type of coffee consumed by the Tromsø sample[(9)]. In Finnmark, the proportion of unfiltered coffee drinkers (five or more cups per day) has decreased since the 1980s. In 1993, 51 % of men and 45 % of women consumed five or more cups of unfiltered coffee per day[(26)]. It seems that a reduction in unfiltered coffee intake has taken place in Norway – even though formal public health intervention strategies to encourage this did not occur. Nevertheless, public awareness through the use of mass media of the cholesterol-increasing effect of unfiltered coffee has been prevalent for decades. In Finland, an identical decreasing consumption tendency has occurred. At the end of the 1960s, the proportion of unfiltered coffee consumption was 75 %, which had decreased to 24 % in 1987[(27)].

Many cross-sectional studies have reported their findings on the association between coffee consumption and cholesterol level. Most of the studies showed a significant positive association; other studies reported no associations[(28)]. However, unfiltered coffee has been shown to elevate total serum cholesterol levels in a dose-dependent manner in, RCT[(16)]. A meta-analysis of 14 RCT showed that the consumption of unfiltered coffee overall increased the serum cholesterol by 0·59 mmol/l[(29)].

The association between unfiltered coffee and cholesterol level is not nearly as strong in the present study as in previous studies[(2,9)]. The explanation might be the decline of unfiltered coffee consumers. In previous cross-sectional studies, the strongest association between coffee consumption and serum cholesterol has been reported in populations with a high consumption of unfiltered coffee[(8,9,30)]. In the United States, where mostly filtered or instant coffee is consumed, no association between coffee consumption and serum cholesterol has been shown[(28)]. This is in agreement with our results with no association between total cholesterol and filtered coffee consumption.

We found a positive association between total cholesterol and total coffee consumption in Norwegian women. These findings were not explained by unfiltered coffee consumption or other confounders such as physical activity in leisure time, BMI, smoking habits and age. A limitation in our study is the lack of information about total fat intake/total energy intake. Several studies have shown that heavy coffee consumers also have a higher intake of fat[(8,31,32)].

Over many decades, drinking unfiltered coffee has been an important element in the traditional Sami diet. It seems that unfiltered coffee has also been exchanged for filtered coffee in the Sami population. Despite higher unfiltered coffee consumption among Sami than Norwegians, no association between unfiltered coffee consumption and total cholesterol has been shown. One explanation might be a lack of statistical power to detect such an association among Sami people, e.g. that the number of participants who were high consumers of unfiltered coffee (nine or more cups) was low in our study.

Most of the published prospective cohort studies have not found a positive association between coffee drinking and CHD risk[(29)]. In the Finnish cohort study, no association between coffee drinking and the risk of non-fatal MI was found, in spite of an increase in the serum cholesterol level with increased coffee consumption[(13)]. A limitation in the present study was that specific types of coffee were not identified. Therefore, the inconsistency among some of the cohort studies might be because of the study design and not considering different methods of coffee preparation.

Since 1974, a CVD screening and intervention programme has been carried out in selected Norwegian counties[(33)]. The aim was to identify CVD risk factors in residents aged 35–49 years. Finnmark County was included because of the high incidence of IHD mortality. During the last 30 years of this programme, mortality from IHD has been reduced. A major contributing factor to this decline has been the decrease in serum total cholesterol concentration, although other factors cannot be dismissed, such as reduced smoking and blood pressure, increased consumption of fruit, vegetables, cod liver and fish oil supplements and better treatment[(34)]. The reduced serum cholesterol was explained by changes in the consumption of milk fat, fat from meat and margarine and the change from drinking unfiltered to filtered coffee. However, in 1993, compared with other counties, Finnmark still showed high values for cholesterol, smoking habits and unfiltered coffee consumption. However, 10 years later, a change from drinking unfiltered to filtered coffee has been observed among the population in northern Norway.

Thelle *et al.*[(28)] concluded that the recommendation to avoid coffee drinking in most populations had no public health concern because the cholesterol-raising effect of coffee drinking is limited. However, on the individual level, the recommendation to reduce coffee drinking in participants with hypercholesterolaemia has been well known. Furthermore, coffee filtration has gained popularity and thus the cholesterol-inducing compounds are largely removed. For adults who consume moderate amounts of coffee, the evidence suggests that health risks are limited[(29)]. In fact, several prospective cohort studies have reported health benefits related to coffee drinking, such as an inverse association with the risk of type 2 diabetes mellitus[(35)].

Conclusion

Unfiltered coffee consumption was lower in the present study compared to previous reports. However, Sami men and women had a higher frequency of unfiltered coffee consumption than Norwegians. In general, total coffee consumption was positively associated with total cholesterol levels. An association between unfiltered coffee consumption and total cholesterol level was found only in Norwegian men.

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